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Impact of Various Desensitizing Agents on the Micro-Tensile Bond Strength of Adhesive Systems: *In-Vitro* Study

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Abstract

Objectives: To assess the influence of various desensitizing agents on the micro-tensile bond strength of various adhesive systems. **Methods:** Fifty extracted human permanent third molars, were sectioned at the cementoenamel junction in order to expose the mid-coronal dentinal tubules in parallel to the occlusal surface using a diamond disc and water coolant. The samples were divided into five groups and each sample was immersed in the respective desensitizing agent (Groups 1 to 5; Group 1- Distilled water, Group 2- Arginine calcium carbonate (Sensitive Pro-Relief Colgate- Palmolive, India, Group 3- Calcium sodium phosphosilicate (Repair and Protect, GlaxoSmithKline, India), Group 4- Strontium chloride hexahydrate 10% w/w (ICPA Health Products Ltd, India.), Group 5- Er,Cr: YSGG (Waterlase MD, Biolase, Irvine, CA, USA) with each group having a sample of n = 10. Each group was further divided into two subgroups (n = 5) based on the adhesive system (either a One-step self-etch adhesive (Xeno v+) (SE) or a two-step etch and rinse adhesive (Prime and Bond NT) (EandR)). Instron Micro tensile Tester was used to analyze the Micro-Tensile Bond Strength (MTBS) of the samples. **Results:** The bond strength of the control group (Group 1) was greater as compared to the other four groups, though statistically insignificant. There was a significant difference in the bond strength of the two subgroups ($p<0.001$) One-step self-etch adhesive (SE, Xeno V+) and two-step etch and rinse adhesive (EandR; Prime and Bond NT) adhesive. **Conclusion:** The use of desensitizing agents does not affect the micro tensile bond strength of adhesives used for the management of restoration of Non-Cervical Carious Lesions (NCCL). Microtensile bond strength with a self-etch adhesive system was significantly lower in the desensitized dentin irrespective of the agents used.

Keywords: Bond Strength, Composite Resin, Desensitizing Agents

1. Introduction

According to the hydrodynamic theory proposed by Barnstorm *et al*., dentinal hypersensitivity is described as a brief, severe pain that is accompanied by external thermal, tactile, evaporative, osmotic, or chemical stimuli of patent tubules[1]. As a result, the nerves depolarize, which is the reason for central pain to be perceived. The severity of the condition increases with age due to the increased prevalence of gingival recession, periodontal disease, and tooth wear which exposes the dentinal tubule to external stimuli[2,3]. The presence of Non-Carious Cervical Lesions (NCCLs) is one of the most significant causes of dentin hypersensitivity[4,5].

Dentinal hypersensitivity can be treated by either a noninvasive or invasive modality depending on the extent. Non-invasive treatment is done by application of dentifrices and topical agents that contain active desensitizing agents[6-8]. These are considered as the first line of treatment for a maximum number of patients. Desensitizing agents physically occlude the dentinal tubules thereby depolarizing the nerve synapse[9,10]. Dentifrices with active agents like oxalate[10,11], strontium[12,13], citrate-based[14], arginine-based compounds[15], and

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potassium-based compounds act by blocking neural transmission at the pulpal tissues.

Various Lasers such as Helium-Neon (He-Ne), Carbon dioxide (CO_2), neodymium-doped: Yttrium Aluminum and Garnet (Nd: YAG), Gallium-Aluminum-Arsenide (GaAlAsDiode), Erbium-doped: YAG (Er: YAG), erbium, chromium doped: Yttrium, Scandium, Gallium and Garnet (Er, Cr: YSGG) are promising new modalities used for desensitization which occlude dentinal tubules by melting and re-crystallization.

Operative and restorative interventions are also indicated in abfraction-related NCCL. It includes conservative bonded restoration or endodontic therapy and periodontal surgical procedures[7].

Although the primary treatment modality is adhesive restoration in cervical defects, however, it is hypothesized that their long-term survival might be compromised due to inadequate bond strength resulting from alteration of tooth surface caused by previous application of desensitizing agents, which act by blocking or obliterating dentinal tubules. This may however limit the adhesive potential of the bonding agent by altering the surface properties of dentin[16]. Different adhesive systems possess distinct dentin bonding mechanisms[7,17]. In addition to the type of mechanisms, etch-and-rinse and one-step self-etching agents may also present variable effectiveness on dentin substrates[18].

There is not much evidence on how tooth surface modifications influence dentine bonding. Therefore, the current study was conducted to assess the effect of desensitizing agents on the bond strength of various adhesives and bonding systems (etch-and-rinse and one-step self-etching adhesives).

2. Materials and Methods

After obtaining informed consent from donors and in accordance with a protocol endorsed by the Ethics Committee, fifty (n = 50) extracted human third molars were collected. Using a water-cooled diamond disc and a slow cutting speed, all teeth were sectioned parallel to the occlusal surface to reveal the mid-coronal dentine tubules. To achieve uniform dentine surfaces, they were polished with 600-grit Silicon carbide (SiC) paper for 60 seconds with coolant. The teeth were etched with a 1% citric acid solution for 20 seconds to mimic the hypersensitive tooth model by exposing dentinal tubules.

The specimens were randomly distributed into 5 groups of 10 samples and each sample was immersed in the respective desensitizing agent, Group 1- Distilled water, Group 2- Arginine calcium carbonate (Sensitive Pro-Relief Colgate- Palmolive, India), Group 3- Calcium sodium phosphosilicate (Repair and Protect, GlaxoSmithKline, India), Group 4- Strontium chloride hexahydrate 10% w/w (ICPA Health Products Ltd, India.), Group 5- Er, Cr: YSGG (Waterlase MD, Biolase, Irvine, CA, USA).

Groups 2, 3, and 4 were brushed with undiluted toothpaste (approximately 1g) with a powered toothbrush (Oral B) at an inclination of 90˚, for 2 min twice daily for seven days. After each brushing session, the specimens were washed with distilled water and kept in artificial saliva at room temperature. Group 5 was subjected to Er, Cr: YSGG laser (Waterlase MD, Biolase, Irvine, CA, USA) on hard tissue mode with a mz6 sapphire tip using non-contact mode at an energy level of 0.25W and a repetition rate of 20 kHz, 0% water and 10% air.

Specimens from groups 1 to 5 were divided into two subgroups each, Subgroup 1- One step self-etch adhesive (Xeno v+, Dentsply Detrey, Konstanz, Germany); Subgroup 2- Etch and rinse adhesive (Prime and Bond NT, Dentsply Detrey, Konstanz, Germany). A silicon mold measuring 8x8x5mm was used for uniform shape of the final experimental restorations. Composite restoration (5mm thick) was constructed in increments with Ceram X Mono Nano hybrid material (Dentsply Detrey, Konstanz, Germany) using LED Curing Light (Unicorn DenMart Limited, India) with an output intensity of 600MW/cm^2 as per manufacturer's instructions. After storage in water for 24 hours, samples were then sliced into 1x1-mm^2 sections using a water-cooled diamond disc (Dentsply DeguDent Twis Tec, Germany). Five beams were chosen from the middle region of each tooth composite specimen, leaving the external beams from the periphery.

The PELCO Pro CA-Gel Glue was used to attach beams from each group to the metal jig. Specimen alignment was improved by the U-shaped groove parallel to the direction of load, as integrated in Geraldeli's Jig. The beams were pulled apart using an Instron Micro Tensile Tester (Model 5848, Singapore), at a crosshead speed of 1 mm/min. The dimensions of each beam were measured using a digital calliper. Additionally, the bonded area was computed in order to convert the values of micro-tensile strength into units of stress (MPa).

SPSS version 20.0 was used for statistical analysis. A One-way ANOVA test was used to compare mean Micro-Tensile Bond Strength (MTBS) between Etch and Rinse (ER) and Self-Etch (SE) adhesive systems for each group.

Table 1. The Mean Micro-Tensile Bond Strength (MTBS) of composite restorations (cervical) after the use of various desensitizing agents (Group 1-5).

Groups (n = 10 each)	Desensitizing Agent	Mean MTBS (MPa)	SD	p-value
Group 1	Control (Distilled water)	28.46	5.758	0.133 (ns)
Group 2	(Arginine calcium carbonate)	26.30	5.032	
Group 3	(Calcium Sodium phosphosilicate)	26.70	4.974	
Group 4	(Strontium chloride hexahydrate)	27.42	5.406	
Group 5	(Er; Cr; YSGG)	26.04	26.04	

Significance at p<0.05; one way ANOVA; MTBS, Micro-Tensile Bond Strength; SD, Standard Deviation.

Post-hoc Tukey's test used for multiple comparisons. The level of significance was set at $P \leq 0.05$.

3. Results

The micro-tensile bond strength of all groups is data is shown in (Table 1). One-way ANOVA Welch test revealed that there was an insignificant difference between the groups that used desensitizing agents before restoration (p >0.05). Group 5 (Er, Cr; YSGG) showed the lowest MTBS compared to the control group (P<0.05). Tukey's post-hoc multiple comparisons revealed that there was a significant difference between the two subgroups (p<0.001) ER and SE adhesives in all experimental groups with lower MTBS for the SE subgroup (Table 2).

4. Discussion

The application of desensitizing agents is usually carried out as initial as well as preventive treatment for dentinal hypersensitivity due to NCCL, which is followed by adhesive restoration. Awang et. al found that due to the limited adhesive infiltration and dentine hybridization after the usage of desensitizers, the bond strength is decreased, which causes the restoration to fail[19].

It was hypothesized that the application of various desensitizers has a negative impact on the micro tensile bond strength of adhesive systems. However, the results of this study showed that the application of desensitizing agents did not significantly affect the MTBS of dentin adhesives. The self-etch adhesive system had significantly lesser bond strength than the total-etch adhesive system.

In vitro experiments on extracted human teeth have the potential for numerous uncontrolled changes. Variables such as tooth type, the level of exposed dentin, the method used to prepare the dentin surface, and the diameter of the bonded region were tried to be controlled and kept uniform as was feasible in the current study. Due to their significantly greater surface area, human mandibular third molars were selected. Occlusal third

Table 2. Comparative MTBS of experimental subgroups based on the adhesive system Self Etch (SE, Xeno v+) vs two-step etch and rinse adhesive (ER, Prime and Bond NT) used after use of desensitizing agents (Group 1-5)

Groups	Subgroup	Sample Size	Mean MTBS (MPa)	+SD	t	p-value
Group 1 (Distilled water)	ER	5	32.2	4.082	6.024	< 0.001
	SE	5	24.72	4.677		
Group2 (Arginine calciumcarbonate)	ER	5	29.56	3.98	5.997	< 0.001
	SE	5	23.04	3.702		
Group 3 (Calcium sodium phosphosilicate)	ER	5	29.76	3.982	7.536	< 0.001
	SE	5	23.64	3.893		
Group 4 (Strontium chloride hexahydrate)	ER	5	31.36	3.999	7.536	< 0.001
	SE	5	23.48	3.368		
Group 5 (Er,Cr;YSGG)	ER	5	29.28	3.879	6.967	< 0.001
	SE	5	22.8	2.566		

T-test values (t).

was removed in order to obtain a uniform depth of exposed dentin throughout the sample. Each sample's dentin surfaces were polished using a universal polisher and 600-grit silicon finishing paper, following the same finishing process. All the samples were stored in artificial saliva for an equal time.

After the desired storage duration, the experimental groups were sectioned using custom-made device. The device was used to attach the slow speed micromotor with a diamond disc on to the Vertical Machining Center (VMC). VMC is a multipurpose high precession sectioning machine with its spindle in vertical orientation. The diamond disc was used to cut slices that were 1mm thick, which were then further processed into sticks that were around 1x1 mm in size. The 1x1mm dentinal beams provide uniform stress distribution and reduced secondary crack formation[20]. The most popular test setting for determining the bonding strength to dentin is now the Microtensile Bond Strength method (MTBS), which has acquired scientific acceptability[20-22].

When the dentin surface was altered using desensitizing chemicals, it was discovered that dentine adhesive systems showed lower bonding strength than the control group, however, this difference was not statistically significant. This can be caused by the dentinal tubule having been eliminated or narrowed by the application of desensitizers. In a previous study, dentine permeability reduction was partially recovered following immersion in citric acid and synthetic saliva[23]. The remaining smear layer and deposits may not be stable in the case of Arg-$CaCO_3$, Calcium sodium phosposilicate, Strontium chloride hexahydrate, and Er, Cr: YSGG treated dentine. Additionally, desensitizing pastes containing calcium may only have a limited amount of acid resistance[23,24]. Therefore, until it finds a mineralized dentine matrix, 34% phosphoric acid conditioning, functionalized phosphoric acid ester, and acrylamide-alkyl sulfonic acid likely dissolve loose calcium and phosphate deposits in dentinal tubules, reopening the tubules.

Andrea, *et al.,* investigated the bonding strength of ER and self-etch systems after and without the use of a desensitizing agent[25]. The authors concluded ER showed higher bond strength than self-etch however the bond weakened if adhesion was attempted on a tooth treated with a desensitizing agent.

The effect of calcium-containing desensitizers (Arg-$CaCO_3$- and Novamin) was assessed on the bond strength of ER adhesives (both 2 step and 3 step), and it was found that treatment with desensitizers could not hamper the strong bond achieved with ER adhesives[26]. The results obtained in our study reveal ER adhesives to be superior to the SE adhesive system in terms of bond strength. This is in agreement with clinical trial D Tuncer, *et al*[27]. It might be explained by the opening of the dentinal tubules and elimination of the smear layer, which is a characteristic of ER adhesives.

Another study looked into how desensitization affected the bond's strength. The application of HEMA/glutaraldehyde, potassium oxalate, and low-intensity laser therapy revealed that bonding strength was considerably weakened[28].

Shirai K, *et al.,* studied various simplified adhesive systems in different cavity configurations after the aging[29]. According to the authors, the acidity of this type of adhesive system, the thickness of the adhesive layer, incomplete wetting, and phase separation between the hydrophilic and hydrophobic components, inhibit composite polymerization, which lowers the long-term bonding performance of simplified adhesives. To improve bonding performance various studies indicated the use of acid etching of enamel before application self-etch adhesives.

5. Conclusion

It can be concluded that the application of desensitizing agents reduces the bond strength of SE adhesives compared to ER adhesives; hence there is a need to devise a protocol to be followed for restoring teeth treated with desensitizing agents. Further research in this area is essential to increase the life span of adhesive restorations. Thus, further studies are required in order to define protocols for the use of self-etching systems on substrates treated with desensitizing agents to have improved bond strength.

6. References

1. Brannstrom M, Linden LA, Arstrom A. The hydrodynamics of dental tubule and pulp fluid. A discussion of its significance in relation to dental sensitivity. Caries Res. 1967; 1:10–7. https://doi.org/10.1159/000259530
2. Rees JS. The prevalence of dentine hypersensitivity in general dental practice in the UK. J Clin Periodontol. 2000; 27:860–5. https://doi.org/10.1034/j.1600-051x.2000.027011860.x
3. Fischer C, Fischer RG, Wennberg A. Prevalence and distribution of cervical dentine hypersensitivity in a

population in Rio de Janeiro, Brazil. J Dent. 1992; 20:272–6. https://doi.org/10.1016/0300-5712(92)90043-C
4. Gillam DG, Seo HS, Bulman JS, Newman HN. Perceptions of dentine hypersensitivity in a general practice population. J Oral Rehabil. 1999; 26:710–4. https://doi.org/10.1046/j.1365-2842.1999.00436.x
5. Tuncer D, Yazici AR, Özgünaltay G, Dayangac B. Clinical evaluation of different adhesives used in the restoration of non-carious cervical lesions: 24-month results. Aust Dent J. 2013; 58:94-100. https://doi.org/10.1111/adj.12028
6. Arrais CAG, Chan DCN, Giannini M. Effects of desensitizing agents on dentinal tubule occlusion. J Appl Oral Sci. 2004; 12:144-8. https://doi.org/10.1590/S1678-77572004 000200012
7. Cummins D. Recent advances in dentin hypersensitivity: Clinically proven treatments for instant and lasting sensitivity relief. Am J Dent. 2010; 23:3-13. https://doi.org/10.4103/0972-0707.73385
8. Walters PA. Dentinal hypersensitivity: A review. J Contemp Dent Pract. 2005; 6:107-17. https://doi.org/10.5005/jcdp-6-2-107
9. Wara-Aswapati N, Krongnawakul D, Jiraviboon D, Adulyanon S, Karimbux N, Pitiphat W. The effect of a new toothpaste containing potassium nitrate and triclosan on gingival health, plaque formation and dentine hypersensitivity. J Clin Periodontol. 2005; 32:53–8. https://doi.org/10.1111/j.1600-051X.2004.00631.x
10. Poulsen S, Errboe M, Lescay Mevil Y, Glenny AM. Potassium containing toothpaste for dentine hypersensitivity. Cochrane Database Syst Rev. 2006; 3:CD001476. https://doi.org/10.1002/14651858.CD001476.pub2
11. Dragolich WE, Pashley DH, Brennan WA, Robert BO, Horner JA, Van Dyke TE. An *in vitro* study of dentinal tubules occlusion by ferric oxalate. J Periodontol. 1993; 64:1045–51. https://doi.org/10.1902/jop.1993.64.11.1045
12. Gillam DG, Mordan NJ, Sinodinou AD, Tang JY, Knowles JC. The effects of oxalate-containing products on the exposed dentine surface: and SEM investigation. J Oral Rehabil. 2001; 28:1037–44. https://doi.org/10.1046/j.1365-2842.2001.00775.x
13. Pearce NX, Addy M, Newcombe RG. Dentine hypersensitivity: A clinical trial to compare 2 strontium desensitizing toothpastes with a conventional fluoride toothpaste. J Periodontol. 1994; 65:113–9. https://doi.org/10.1902/jop.1994.65.2.113
14. Chesters R, Kaufman HW, Wolff MS, Huntington E, Kleinberg I. Use of multiple sensitivity measurements and logit statistical analysis to assess the effectiveness of a potassium-citrate-containing dentifrice in reducing dentinal hypersensitivity. J Clin Periodontol. 1992; 19:256–61. https://doi.org/10.1111/j.1600-051X.1992.tb00463.x
15. Petrou I, Heu R, Stranick M, Lavender S, Zaidel L, Cummins D, Sullivan RJ, Hsueh C, Gimzewski JK. A breakthrough therapy for dentine hypersensitivity: How dental products containing 8% arginine and calcium carbonate work to deliver effective relief for sensitive teeth. J Clin Dent. 2009; 20:23–31.
16. Pashley DH, Carvalho RM, Pereira JC, Villanueva R, Tay FR. The use of oxalate to reduce dentin permeability under adhesive restorations. Am J Dent. 2001; 14:89-94
17. Silva e Souza Jr MH, Carneiro KG, Lobato MF, Silva e Souza P de A, de Góes MF. Adhesive systems: Important aspects related to their composition and clinical use. J Appl Oral Sci. 2010; 18:207-14. https://doi.org/10.1590/S1678-77572010000300002
18. Pereira PN, Okuda M, Sano H, Yoshikawa T, Burrow MF, Tagami J. Effect of intrinsic wetness and regional difference on dentin bond strength. Dent Mater. 1999; 15:46-53. https://doi.org/10.1016/S0109-5641(99)00013-5
19. Awang RAR, Masudi SM, Mohd Nor WZW. Effect of desensitizing agent on shear bond strength of an adhesive system. Arch Orofac Sci. 2007; 2:32-5.
20. Pashley DH, Carvalho RM, Sano H, Nakajima M, Yoshiyama M, Shono Y, Fernandes CA, Tay F. The microtensile bond test: A review. J Adhes Dent. 1999; 1:299-309.
21. Armstrong SR, Geradeli S, Maia R, Raposo LHA, Soares CJ, Yamagawa J. Adhesion in dentistry – analyzing bond strength test methods, variables and outcomes. Adhesion to tooth structure: A critical review of "micro" test methods. Academy of Dental Materials Annual Meeting – Portland, Oregon, USA. 2009; 29-31.
22. Inoue S, Vargas MA, Abe Y, Yoshida Y, Lambrechts P, Vanherle G, Sano H, Van Meerbeek B. Microtensile bond strength of eleven contemporary adhesives to dentin. J Adhes Dent. 2001; 3:237-45.
23. Wanga Z, Sa Y, Sauro S, Chen H, Xing W, Maa X, Jiang T, Wanga Y. Effect of desensitizing toothpastes on dentinal tubule occlusion: A dentine permeability measurement and SEM *in vitro* study. J Dent. 2010; 38:400-10. https://doi.org/10.1016/j.jdent.2010.01.007
24. Banomyong D, Kanchanasantikul P, Wong RH. Effects of casein phosphopeptide-amorphous calcium phosphate remineralizing paste and 8% arginine desensitizing paste on dentin permeability. Journal of Investigative and Clinical Dentistry. 2013; 4:200–6. https://doi.org/10.1111/j.2041-1626.2012.00144.x
25. Cavalcanti AN, de Souza ES, dos Santos Lopes G, de Freitas AP, de Araújo RPC, Mathias P. Effect of a desensitizing dentifrice on the bond strength of different adhesive systems. Braz J Oral Sci. 2013; 12. https://doi.org/10.1590/S1677-32252013000200015
26. Yang H, Pei D, Chen Z, Lei J, Zhou L, Huang C. Effects of the application sequence of calcium-containing desensitising

pastes during etch-and-rinse adhesive restoration. J Dent. 2014; 42:1115-23. https://doi.org/10.1016/j.jdent.2014.03.018

27. Tuncer D, Yazici AR, Özgünaltay G, Dayangac B. Clinical evaluation of different adhesives used in the restoration of non-carious cervical lesions: 24-month results. Aust Dent J. 2013; 58:94-100. https://doi.org/10.1111/adj.12028
28. Aranha ACC, Siqueira Junior CADS, Cavalcante LMA, Pimenta LAF, Marchi GM. Microtensile bond strengths of composite to dentin treated with desensitizer products. J Adhes Dent. 2006; 8:85-90.
29. Shirai K, De Munck J, Yoshida Y, Inoue S, Lambrechts P, Suzuki K, *et al*. Effect of cavity configuration and aging on the bonding effectiveness of six adhesives to dentin. Dentet al Mater J. 2005; 21:110-24. https://doi.org/10.1016/j.dental.2004.01.003